Correlation of Radar Reflectivity and Lightning (CoRRaL) Study

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Agenda

- Program Background
- CoRRaL Overview
- Objectives
- Approach
- Aircraft Equipment and Modifications
- Flight Procedures and Operational Plans
- Schedule, Status, Initial Observations

Program Background

- Aviation Weather Information (AWIN)
  - Safety program element
  - Reduce weather-related accidents … by 50% w/in 10 years
  - Provide better weather information for many aircraft types, operators, flight regions, and weather hazards.

- CoRRaL Study
  - Supports convective weather hazard avoidance by pilots of small general aviation (GA) aircraft (potentially extendable to other A/C)
  - Supports design/use guideline development for future data-linked lightning (DLL) weather information products
  - Investigates earliest detection of airmass thunderstorms

The Weather Information Environment for Small GA Airplanes

- Most have no onboard hazardous weather information devices
- Some have onboard lightning detectors (e.g., Stormscope, StrikeFinder)
- Far fewer have (limited-capability) onboard weather radar
- Data-linked AWIN systems are coming quickly
  - First with data-linked radar mosaic products
  - Soon with data-linked lightning products, but we don't know how to do them yet
- Which products are best, under what conditions? Can one replace another? How should they be displayed/used, either separately or together?

CoRRaL Overview

- Observe airmass thunderstorm development, from a safe distance
- Record airborne-sensed data: weather radar, lightning, cloud height
- Record ground-based data: radar mosaic, lightning, cloud height/growth
- Compare data sources and correlate post hoc

CoRRaL Weather Sources

- Next-Generation WSR-88D Doppler Radar (NEXRAD)
- NEXRAD Information Distribution Service (NIDS) Radar Mosaic
- Data-Linked Radar (DLR)
- Onboard Weather Radar (OWR)

- KSC Lightning Detection and Ranging (LDAR) system
- National Lightning Detection Network (NLDN)
- Data-Linked Lightning (DLL)
- Onboard Lightning Detection (OLD)

- Cloud Height and Growth Rate (CHGR)

CoRRaL Objectives - General

- Obtain a Database of Weather Information Sources for Developing Airmass Thunderstorms
  - Onboard and ground-based weather radar, lightning detection
  - Cloud height and growth rate
- Use the Database to Develop AWIN Guidelines for:
  - Datalinked lightning products
  - Composite weather products
  - Pilot use of weather products
- Enhance the Infrastructure for AWIN Experiments
  - Upgraded radar & commercial AWIN system on Langley's B-200
  - Provides learning opportunities: AWIN avionics & weather ops.
  - Potential reuse for later AWIN experiments

CoRRaL Objectives - Specific

Answer these questions using collected weather source information:

1. How would a NLDN-based DLL product compare with an OLD (and LDAR "ground truth" data) in bearing & range accuracy?

2. How quickly could a NLDN-based DLL product detect developing convective activity, compared to LDAR, OLD, NEXRAD, NIDS, DLR, OWR, and CHGR?

3. Given the answer to question 2, what are the optimal time/space "batching" rates for a DLL product, given limited data-link bandwidth?

4. Given the answer to questions 2 and 3, is there potential to safely use a DLL product tactically, in lieu of OWR and/or OLD?

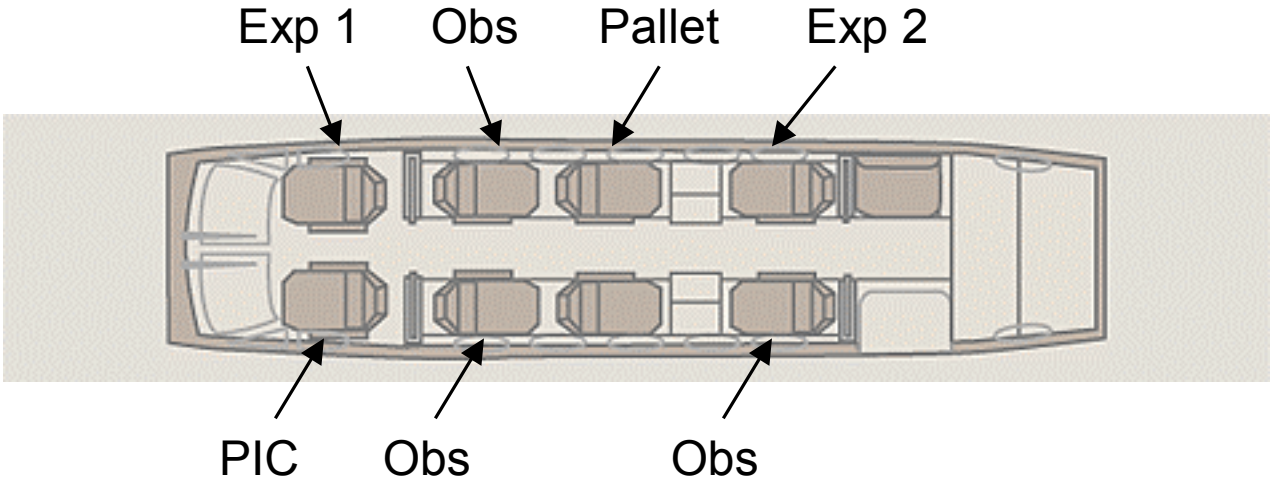
Approach

- Install upgraded, FAA-approved OWR, DLR, and OLD avionics in B-200
- Verify avionics operation, and gain familiarity with its use, within approximately 400 nm of Langley
- Develop and install “portable” data recording equipment in B-200, similar to prior experiments
- Conduct flights on convective weather days; obtain video and audio records of weather source information
  - First within ~400 nm of Langley
  - Then on overnight deployments to KSC, FL area (for Lightning Detection and Ranging (LDAR) comparisons)
  - Concurrent use of a ground observer at KSC

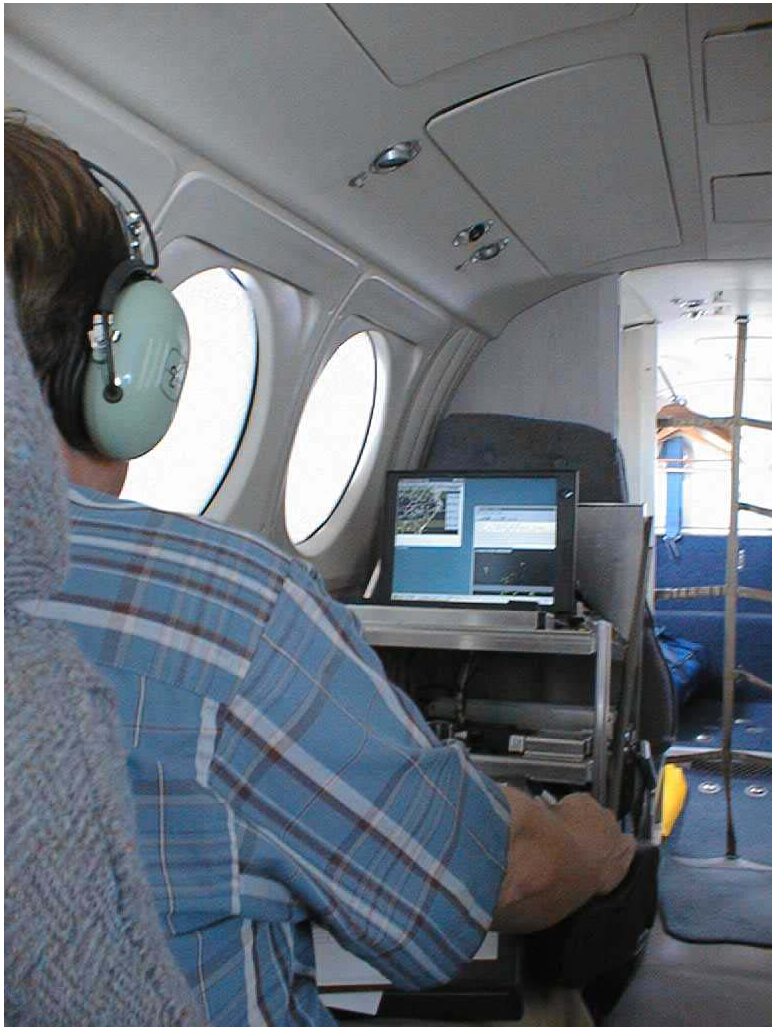
Aircraft Equipment Requirements

- B-200 avionics upgrades
  - Bendix-King digital radar, weather datalink radio, GPS, and multifunction display; Stormscope lightning detector
  - Cabin headset intercom system
- Flight deck-mounted video cameras for out-the-window, multifunction display, and flight instrument recording
- Seat-mounted equipment pallet for
  - Digital video recorders (DVRs)
  - Video time-code generators for DVRs
  - Laptop and GPS receiver

B-200 Super King Air



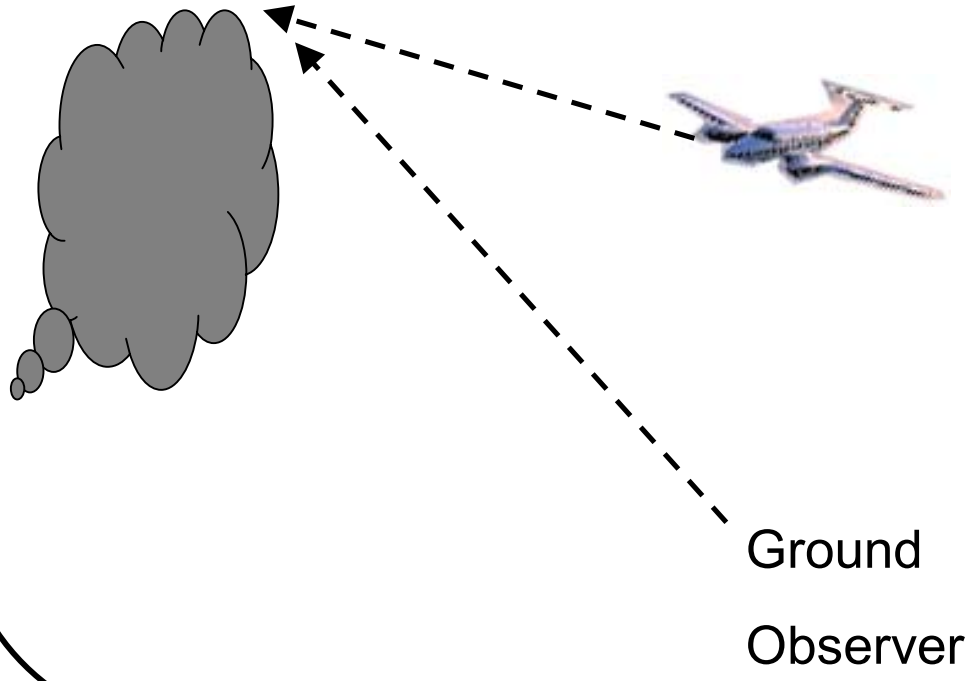
CoWS Pallet Installed in the B200

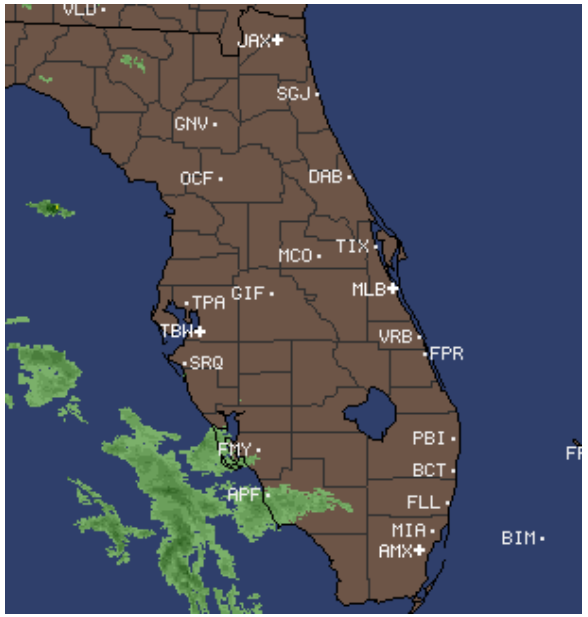



NASA

Flight Test Scenarios

- Approach identifiable airmass towering cumulus/cells using a modified “racetrack” pattern, approximately overhead a ground observer’s position
- Take ground & airborne azimuth, elevation measures





Scenario Specifics

- "Scan" Mode
  - Aircraft flies wide circles at ~freezing level, ~170 KTAS
  - Candidate cells selected as they pass through A/C altitude
- "Cell Data Collection" Mode
  - A/C flies "racetrack" holding pattern toward cell, with ground observer as "holding fix"
  - Inbound leg: OLD/reset; OWR plan & profile plus elevation measurement; DLR; OLD
  - Outbound turn/leg, inbound turn: scan mode; ground coordination; passive OLD acquisition
- Goal is data from 10-20 cells

Operational Plans

- Local flights
  - Depart from and return to Langley (LFI), same day
  - May use other nearby airport (e.g., PHF) if necessary
- Kennedy Space Center (KSC) deployments
  - Deploy for 2-4 days (2- overnights) at a time
  - Operate out of Shuttle Landing Facility (X68) and Patrick Air Force Base (COF), with Space Coast Regional (TIX) as a backup

Status & Schedule

• ASRB Preliminary Briefing	6/5/02
• B-200 Avionics Upgrades Complete	7/5/02
• Avionics Checkout, Fam Flights	7/8/02 - 7/19/02
• KSC, Patrick AFB Coordination Trip	8/4/02 - 8/6/02
• ASRB Operational Safety Review	8/7/02
• LaRC-Based Fab; Checkout Flights	8/8/02 - 9/13/02
• KSC-Deployment	9/15/02 - 9/18/02
• “Wait for Weather”; Camera Upgrade	10/31/02 - 3/31/03
• KSC Deployments	4/1/03 - 9/30/03

Initial Observations

- Based on 9/17/02 KSC flight, four distant cells:
  - DLR display is surprisingly sensitive to building cells
  - DLR use is lower workload than OWR
  - OLD may be detecting some intra-cloud lightning
  - Towering cumulus could yield a “wild ride” before anything shows it
- Based on en route observations:
  - DLR appears to over-predict severity vs visual observations, tops
  - DLR can be misleading if used to find “soft spots” in a line
- Quantitative results expected after summer ‘03 flights

Backup Charts

CoRRaL Weather Source Definitions

- Next-Generation WSR-88D Doppler Radar (NEXRAD)
  - Individual NWS sites; most detailed weather radar info; 5-6 minute cycle; base for NIDS mosaic products
- NEXRAD Information Distribution Service (NIDS) Radar Mosaic
  - Blended mosaic of individual NEXRAD site data; 3 providers; 6+ minutes old; base for DLR products
- Data-Linked Radar (DLR)
  - Lower-resolution data-linked NIDS mosaic overlaid on a moving-map display; 6+ minutes old
- Onboard Weather Radar (OWR)
  - Real-time radar image as “seen” ahead of aircraft; limited view angle; power, tilt mgmt., attenuation issues

- KSC Lightning Detection and Ranging (LDAR) system
  - State-of-the-art, precise 4-D VHF-based “ground truth” lightning detection system (IC, C-C, C-G)
- National Lightning Detection Network (NLDN)
  - Near-real-time (~30 seconds) national lightning detection system; currently C-G only, possible source for DLL
- Data-Linked Lightning (DLL)
  - Future product, possibly based on time/space-condensed NLDN data; near-real-time w/ precise strike locations
- Onboard Lightning Detection (OLD)
  - Real-time onboard sensor; good azimuth info but imprecise range; lots of pilot experience & usage lore

- Cloud Height and Growth Rate (CHGR)
  - To be measured by ground & airborne observers; possible “earliest convective activity detector”

CoRRal Equipment Block Diagram